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# The Dual Crisis in Science and Society*

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Our present achievements in science and technology appear to contrast vividly with our present lack of achievement in solving social problems. We can nourish a man in the supreme isolation of outer space—but we cannot adequately feed the children of Calcutta or Harlem. We hope to analyze life on other planets—but we have not yet learned to understand our own neighbors. We are attempting to live on the moon—but we cannot yet live peacefully on our own planet.

The usual explanation of this frightening paradox is that we are competent in the realm of science because no value judgments are demanded and that we are tragically incompetent in dealing with each other because this requires adjustment between personal values and the social good—a capacity that frequently eludes us.

I should like to propose another explanation—that the contrast between our technological competence and our ethical inepitude is only apparent. We are tragically blind, I believe, not only about our fellowmen but also about important aspects of nature; we are dangerously incompetent in our relations to the natural world as well as in our relations to each other.

Our society is threatened not only by a growing social crisis but also by a technological crisis. In our eager search for the benefits of modern science and technology, we have blundered unwittingly into serious hazards:

We used to be told that nuclear testing was perfectly harmless. Only now, long after the damage has been done, do we know differently.

We produced power plants and automobiles that enveloped our cities in smog—before anyone understood its harmful effects on health.

We synthesized and disseminated the new insecticides—before anyone learned that they also kill birds and might be harmful to people.

We produced detergents and put billions of pounds of them into our surface waters—before we realized that they would pollute our water supplies because they do not break down in our disposal systems.

We are now, in Vietnam, conducting chemical warfare with herbicides, although we cannot predict the con-

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sequences of this novel type of warfare.

We are fully prepared to conduct a nuclear war—even though we do not know whether its vast effects on life, on soil, and on the weather will destroy our civilization.

Clearly, we have compiled a record of serious failures in recent encounters with the environment. This record shows that we have thus far failed to understand the environment well enough to make new large-scale intrusions on it with a reasonable expectation of accurately predicting the consequences.

This failure raises two important questions about the relation between science and technology and human values. What are the relative roles of science and human desires in the resolution of the important issues generated by our failures in the environment? What are the causes of these failures, and how do they illuminate the dual crisis in technology and human affairs? How can we resolve the grave public issues that have been generated by our new assaults on the integrity of the environment?

Sometimes it is suggested that since scientists and engineers have made the bombs, insecticides, and autos, they ought to be responsible for deciding how to deal with the resultant hazards.

More cogently, it is argued that scientists and technologists are uniquely competent to resolve these issues because they are in possession of the relevant technical facts that are essential to an understanding of the major public issues generated by new technology. Since scientists are trained to analyze the complex forces at work in such issues, they have a capacity for rational thought that renders them to some degree detached from the emotions that encumber the ordinary citizen's views of these calamitous issues.

In my view, this argument has a basic flaw—the resolution of every social issue imposed on us by modern scientific progress can be shown to require a decision based on *value judgments* rather than on objective scientific laws.

What scientific procedure can determine, for example, whether the benefits to the national interest of nuclear testing outweigh the hazards of fallout? How can scientific method determine whether the proponents of urban superhighways or those who complain about the resultant smog are in the right? What scientific principle can tell us how to make the choice—which may be forced upon us by the insecticide problem—between the shade of the elm tree and the song of the robin?

Certainly, science can validly describe the hard facts about these issues. But the choice of the balance point between benefit and hazard is a value judgment; it is based on ideals of social good or mortality or religion —not on science. And if this choice is a social and moral judgment, it ought to be made, not by scientists and technologists alone, but by all citizens.

How can a citizen make such judgments? Deciding these issues requires a confrontation between human values and rather complex scientific data that most citizens are poorly prepared to understand.

The solution demands a new duty of scientists. As the custodians of the technical knowledge relevant to these public issues, scientists have an obligation to bring this information before their fellow citizens in understandable terms.

But first, scientists themselves must determine the causes of our recent failures in the environment and learn from such a determination about the relationship between science and technology and human values. If we are to succeed as inhabitants of a world increasingly transformed by technology, we need to undertake a searching reassessment of our attitudes toward the natural world and the technology that intrudes on it.

Among primitive people, man is always seen as a dependent part of nature, a frail reed in a harsh world, governed by immutable processes that must be obeyed if he is to survive. And the knowledge of nature achieved by primitive peoples is remarkable.

The African bushman's habitat is one of the most stringent on earth: Food is scarce; water, even more so; and extremes of weather come rapidly. The bushman survives in this environment because his understanding of it is incredibly intimate. A bushman can, for example, return after many months and miles of travel to find a single underground tuber, noted in his previous wanderings, when he needs it for his water supply.

We claim to have escaped from such dependence on the environment. While the bushman must squeeze water from a searched-out tuber, we get ours by the turn of a tap. Instead of trackless wastes, we have the grid of city streets. Instead of seeking the sun's heat when we need it and shunning it when it is too strong, we warm ourselves or cool ourselves with man-made machines. And we have thus become enticed into the nearly fatal illusion that we can ignore the balance of nature.

The truth is tragically different. We have become not less dependent on the balance of nature but more dependent on it. Modern technology has so stressed the web of processes in the living environment that there is little leeway left in the system.

I would contend, therefore, that despite our vaunted mastery of nature, despite our brilliant success in managing those processes that can be confined to a laboratory or a factory, we in the "advanced" countries are far less competent inhabitants of our environment than bushmen are of theirs.

This reflects, I believe, a basic inadequacy in modern science—neglect of systems and processes that are intrinsically complex. The systems at risk in environmental pollution are natural, and because they are natural they are complex. Hence they are not readily approached by the atomistic methodology so characteristic of much of modern biological research.

Water pollutants stress the total ecological web that ties together the numerous organisms inhabiting lakes and rivers; their effects on the whole natural system are not adequately described by laboratory studies of pure cultures of separate organisms. Smog attacks the self-protective mechanism of the human lung; its noxious effects on man are not accountable by an influence on a single enzyme or even a single tissue.

If, for the sake of analytical detail, molecular constituents are isolated from the smashed remains of a cell or single organisms are separted from their natural neighbors, what is lost is the network of interrelationships that crucially determines the properties of the natural whole. And this suggests that any new basic knowledge, if it is to elucidate environmental biology and guide our efforts to understand and control pollution, must be relevant to the natural biological systems that are the arena in which these problems exist.

Nor is our neglect of complex systems limited to environmental biology. This is quickly revealed, for example, by a brief inquiry into the state of modern computer science. Shortly before he died, Norbert Wiener, the mathematician who did so much to develop cybernetics, the science that guides the design of computers, warned us about the problem. He cited, as a parable, experience with computers that had been programmed to play checkers. Engineers built into the electronic circuits a correct understanding of the rules of checkers and also a way of judging (from a stored record of its opponents' moves) what moves were most likely to beat the human opponents.

Dr. Wiener described the results of the checker tournaments between the computer and its human programmers: The machine started out playing an accurate but uninspired game that was easy to beat; but after about 10 or 20 hours of practice, the machine got the hang of it, *and from then on the human player always lost and the machine won.*

Dr. Wiener concluded that it had become technically possible to build automatic machines able to carry out very complex activities that elude the comprehension of their operators and that "most definitely escape from the complete effective control of the man who has made them."

Recently this difficulty has become painfully evident to the specialists who are attempting to manage the operation of the current generation of electronic computers. They are extraordinarily frustrated men. They have at their disposal beautifully designed machines capable, in theory, of complex interdigitation of numerous mathematical operations. However, the operators have not yet learned how to operate these machines at their full capacity for complex computations without encountering inexplicable errors.

A spectacular example of a similar difficulty is the New England power blackout of November 1965, in which a complex powerline network designed to effect an even distribution of generating capacity over an 80,000-square-mile area failed. Instead of providing outside power to a local Canadian power system that had suffered a relay failure, the network acted in reverse, causing every connected power system to shut down. And a frightening potential catastrophe lies in the possibility that the complex, computer-guided missile systems—which can in minutes thrust us into the last World War—are equally susceptible to such failures.

It is not a coincidence, I believe, that the scientific and technological problems affecting the human condition involve inherently complex systems. Life, as we live it, is rarely encompassed by a single academic discipline. Real problems that touch our lives and impinge on what we value rarely fit into the neat categories of the college catalog: medieval history, nuclear physics, molecular biology.

For example, to encompass in our minds the terrifying deterioration of our cities we need to know not only the principles of economics, architecture, and social planning, but also the chemistry of air quality areas, the biology of water systems, and the ecology of the domestic rat and the cockroach. In a word, we need to understand science and technology that are relevant to the human condition.

However, we, in the university community, have been brought up in a different tradition. We have a justified pride in our intellectual independence and know—for we often have to battle to maintain it—how essential this independence is to the search for truth. But academic people may sometimes tend to translate intellectual independence into a kind of mandatory disinterest in all problems that do not arise in their own minds—an approach that may in some cases cut them off from their students and from the real and urgent needs of society.

I believe we university scientists have a clear obligation to the society that supports us. We have no right to retreat behind the walls of our laboratories; instead, we must use our knowledge to help improve the world.

If we accept this obligation, how can we make it jibe with the principle of academic freedom, which holds that every scholar should be free to pursue the studies that interest him and free to express whatever conclusions the evidence and the powers of his mind may generate?

There is no simple answer to this question, but Alexander Meiklejohn, who contributed much to the making of the modern American university, gave us a useful guide. According to Meikeljohn, academic freedom is not a special immunity from social responsibility but, on the contrary, a basic part of the duty that the university and the scholar owe to society.

The university, he believed, is an instituiton established by society to fill its own need for knowledge about the nature of the world and man. The scholar's search for the truth is thus not merely an obligation to himself, to his profession, or to the university, but to society. And in this search, open and unconstrained discourse is essential, for no scholar's work is complete or faultless.

Our duty, then, is not to truth for its own sake, but to truth for society's sake. In Meiklejohn's words: "Our final responsibility as scholars and teachers is not to the truth. It is to the people who need the truth." Hence, the scholar's duty inevitably becomes coupled with social issues. The scholar will become concerned not only with social needs, but with social goals as well. And if society expects the scholar to honor a duty toward the development of socially significant knowledge, society must equally honor his freedom openly to express a concern with social goals. Those whom we serve should see in our zeal for this freedom not the selfish exercise of privilege, but a response to these solemn obligations.

The academic world is now emerging from a long period of silence, a silence that has obscured the true purpose of the university and has weakened its service to society. We now hear many new voices in the universities. Some speak in the traditional well-modulated language of the scholar, some in the sharper tones of dissent, and some in a new language that is less concerned with transmitting ideas than feelings. But behind nearly all the voices is a mutual concern with the quality of life.

Among our students this concern is often reduced to its most elementary level—a demand for the right to life itself. And this is natural, for our students represent the first generation of human beings who have grown to adulthood under the constant threat of instant annihilation.

Our own generation is often criticized because we have, with our own minds and hands, created the weapon of total human destruction; we invented the first atomic bomb. But an even greater sin is that our generation has become numb to the frightful meaning of what we have done.

The newer generation has a different way of sensing things. If nuclear death threatens our generation with an earlier end to a life already in part fulfilled, it threatens our students with the total loss of a life yet to be fulfilled. They, far better than we, can sense the total inhumanity of the civilization that we share.

If they fail to suggest a reasonable way out, the more thoughtful of them have at least defined what it is that we must try to escape. We need the sharpness of their definition of the issue; they need from us the competence and steady purpose that is the gift of experience. Together we can, I believe, secure for all of us what is so gravely threatened by the dual crisis in science and in society—a technology that serves the life of man and a society that cherishes the right to life.

## Rock and Mineral Exchange Service

Elementary and Secondary school science teachers interested in swapping rocks, minerals, and other earth science materials are hereby notified that a clearinghouse for earth science materials exchange has been established in Arlington Heights, Illinois.

To take advantage of this free, volunteer service, send a list (with quantities) of minerals, rocks, fossils, or earth science curriculum materials *you want,* and a list of materials (with quantities) *you can swap,* to Mr. Charles A. Wall, Science Department, South Junior High School, 301 West South Street, Arlington Heights, Illinois 60005. Be sure to enclose a stamped, self-addressed envelope with your request.

You will be supplied with the names and addresses of people who can supply your needs on a swap basis.